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EXTREMELY LOW ENERGY ELECTRON STUDIES OF GASES USED AS HIGH-VOLTAGE INSULATORS

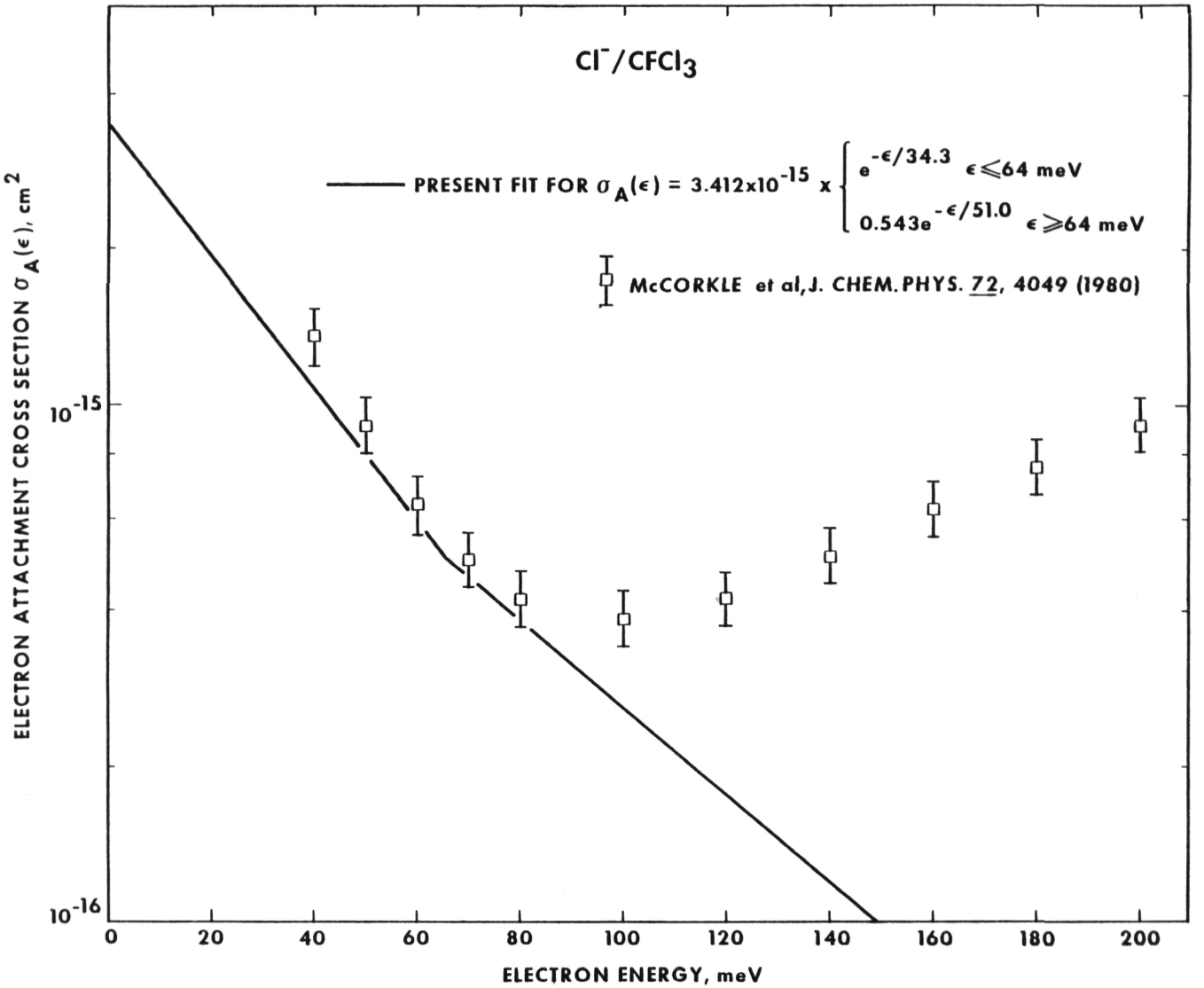
The search for more efficient methods of transporting electrical energy has steadily increased line voltages at which power must be transmitted. Projected transmission line voltages are now in the range of 1 to 1.5 megavolts. This increase is necessitating the development of better gaseous insulators for use in underground transmission lines, circuit breakers, and switch gear.

Studies are under way in several laboratories to "custom design" a unitary or multicomponent gas mixture to a particular line voltage, electrode geometry, or operating pressure. Such studies require knowledge of the basic physics and chemistry of each gas and, then, of the mixture. This basic understanding entails knowledge of thermal ("zero energy") attachment cross sections, positions and cross sections of non-thermal negative-ion resonances, and electron-scattering and ionization cross sections.

Using the technique of Threshold Photoelectron Spectroscopy by Electron Attachment (TPSA) developed at JPL, researchers were able, for the first time, to measure absolute electron attachment cross sections in sulfur hexafluoride (SF_6), a gas traditionally used as a dielectric insulator, and in trichlorofluoromethane ($CFCl_3$), a new candidate for such purposes. In a high-voltage environment, the object is to convert as many free electrons to molecular negative ions as possible. By using attachment cross sections, researchers described the process by which a fast electron is converted to a slow ion. This attachment also inhibits the development of coronal activity and a breakdown in the ambient gas.

In the TPSA technique, a mixture of xenon gas and SF_6 is photoionized by monochromatic light from a vacuum ultraviolet light source. Electrons having a narrow band of energies (7 meV wide) and of very low energy epsilon (variable in the range 0-200 meV) are generated in situ in a field-free region via the xenon photoionization. These electrons then attach to the SF_6 to form SF_6^-. Detection of the mass-analyzed SF_6^- current versus photoionization wavelength gives the relative electron attachment cross section for the attachment process.

The figure opposite shows a comparison of the two approaches for the electron attachment process $Cl^-/CFCl_3$; i.e., that in which a thermal electron attaches to $CFCl_3$ to yield a Cl^- (negative chlorine) ion and a $CFCl_2$ (dichlorofluoromethane) radical. The excellent agreement at electron energies below 100 meV of the TPSA technique with previous measurements indicates that (a) the integrated rate coefficient and the swarm-measured $\sigma_A(\varepsilon)$ are consistent with one another, and (b) the TPSA-measured lineshape is the correct shape for describing the attachment process down to electron energies of zero meV, where measurements by any other technique are not possible. In fact, by this very simple approach JPL lays claim to the world's indoor record for experiments done at the lowest electron energy and at very high electron resolution! The difference in the figure between the solid line and experiment points at $\varepsilon \geq 100$ meV arises from extra negative-ion signal in the swarm data that was purposely excluded from the TPSA data.



Comparison of the present TPSA cross section as calibrated to the integrated rate coefficient, with swarm cross sections. This result represents the consistency of the TPSA technique with two very different sets of experimental measurements.